2006 Present Landfill and Original Landfill Revegetation Monitoring

Introduction

The Rocky Flats Site (Site), a U.S. Department of Energy facility, is located near Golden, Colorado. For nearly 40 years during the Cold War, the Site was an integral part of the United States nuclear weapons program, producing nuclear weapons components. In the early 1990s the Site was shut down and cleanup and closure activities began. As part of the cleanup and closure of the Site, the buildings, roads, and other infrastructure in the Industrial Area were removed. At the conclusion of the Present Landfill (PLF) and Original Landfill (OLF) Projects, both areas were revegetated with native plant species to provide a vegetation cover on each landfill. As part of the revegetation process, monitoring is conducted to evaluate the status of the vegetation. The Rocky Flats, Colorado, Site Revegetation Plan (Revegetation Plan; DOE 2005) provides initial success criteria for revegetation areas at the Site. As stated in the plan the success criteria contained in the Revegetation Plan are simply initial guidance and may be modified using professional judgment, scientific data, and common sense to determine whether the vegetation establishment at a given location is acceptable for the specific location(s). This report summarizes the revegetation monitoring results for data collected at the PLF and OLF during 2006.

Methods

Semi-quantitative revegetation monitoring was conducted during late summer to evaluate the establishment of vegetation at the PLF and OLF in 2006. The PLF was divided into three revegetation sampling units, two on the cover and one on the east face (Figure 1). The OLF was sampled as one unit (Figure 1). Within each revegetation unit, sample locations were randomly generated in the GIS and then located on the ground for monitoring. Quadrats (0.5 m^2; 50 cm × 100 cm) were used to sample the vegetation. A total of 15 quadrats were sampled on each half of the cover at the PLF, with an additional 10 quadrats sampled on the east face of the PLF. The top of the cover was roughly split in half because the eastern and western areas differed somewhat in the soil materials that were placed on each half. So the sampling was designed to see if there was a difference in the vegetation. The OLF had a total of 30 quadrats sampled across the face of the cover. At each quadrat, both species richness and species cover were sampled. A species was listed as present for a quadrat if any part of the plant was located within or overhung inside the quadrat boundary. Cover was estimated for each species using the following cover class system and midpoints (in parentheses): 1 = <5% (2.5%), 2 = 6-25% (15%), 3 = 26-50% (37.5%), 4 = 51-75% (2.5%), 5 = 75-95% (85%), 6 = >95% (97.5%).

Species lists were generated for each revegetation unit by combining all the quadrat data for that unit. Foliar cover by species was averaged across all the quadrats sampled for each revegetation unit. Foliar cover data are reported as the percent absolute cover and percent relative cover for each species encountered. The percent absolute foliar cover was calculated as the sum of all cover values for a species in a revegetation unit divided by the number of quadrats sampled in that unit. Relative foliar cover was calculated as the sum of all cover values for a species in a

revegetation unit divided by the sum of all cover values for all species in the same revegetation unit, multiplied by 100.

Results and Discussion

Species richness in 2006 at both the PLF and OLF is presented in Table 1. Total species richness at the PLF was 35 species in 2006, while the OLF had 15 species. Much of this is related to the fact that 2006 was the second growing season for the PLF, while 2006 was really the first growing season for the OLF since the projects were completed. Additionally, the drought in 2006 limited germination and establishment on the south-facing OLF. At the PLF, a total of eight seed species were present in 2006. Table 2 lists the species that were seeded at each landfill. At the OLF, a total of four seeded species were present in 2006. One of the success criteria in the Revegetation Plan (K-H 2005) states that at least 50% of the seeded species must be present in an area for it to be considered successful. Table 3 lists the location, number of seeded species, number of species present at the location, and percentage present at each location in 2006. All four sampled areas on the landfills met this criteria in 2006.

Ground cover protection from rock, litter, and current year live vegetation was above 95% at both the PLF and OLF (Table 4). The occasional value over 100% is a result of the cover class system used for estimating cover which estimates cover values into a range and uses the midpoint of the cover class for analysis. Another success criterion outlined in the Revegetation Plan (K-H 2005), states a minimum of 70% total ground cover comprised of litter cover, current year live vegetation basal cover, and rock cover is to be present to help prevent erosion. At each of the locations on the PLF and OLF most of the ground cover came from litter, which at this time represents the erosion matting. In time the litter cover will continue to remain the dominant ground cover but it will come from dead plant material that is matted down, rather from the erosion matting. The bottom line is that at both locations there is substantial protection on the soil surface to prevent erosion.

A third success criterion outlined in the Revegetation Plan (K-H 2005), states that a minimum of 30% relative cover of desired species must be present and a forth criterion states that no single species comprise more than 45% of the total relative cover. Table 5 summarizes the foliar cover data for the PLF and OLF by location for 2006. The shaded row titled Total Native Cover represents the percentage of desired species at each location. The relative cover values at individual locations that are higher than 30% are shaded, indicating these locations have met this success criterion. This criteria was met at both the PLF and OLF in 2006. Based on actual absolute cover, however, the total actual amount of vegetation cover would have only met at the East and West PLF cover locations with approximately 35% cover at each area. The East Face of the PLF and the OLF still had much lower vegetation cover present on them in 2006. The dominant species on the cover of the PLF were slender wheatgrass (*Agropyron caninum* [=*Agropyron trachycaulum*]), side-oats grama (*Bouteloua curtipendula*), big bluestem (*Andropogon gerardii*), and western wheatgrass (*Agropyron smithii*). The East Face of the PLF was dominated by slender wheatgrass, western wheatgrass, side-oats grama, and blue grama (*Bouteloua gracilis*). Weed cover from forbs on the PLF was not very high in 2006 because most of the top had been treated with Milestone (aminopyralid) in spring of 2006 to keep the weeds down to allow for better establishment of the graminoids. On the OLF, the dominant species were slender wheatgrass, western wheatgrass, and wheat (*Triticum aestivum*). The relative cover of slender wheatgrass on the West PLF area was above the 45% value for a single species.

Otherwise no other species comprised greater than 45% of the relative cover at either the PLF or OLF.

Table 6 presents a summary of the pass/fail criteria for each revegetation areas at the PLF and OLF monitored in 2006. Three of the four locations passed all four criteria in 2006. The only area that did not pass was the East Face of the PLF which had greater than 45% cover of slender wheatgrass. An important issue to keep in mind when considering success criteria are that the criteria listed in the Revegetation Plan are an initial set of criteria established primarily for erosion protection. As stated in the Revegetation Plan, these "...criteria are provided as initial guidance; however, common sense combined with scientific data will need to be applied to final evaluations to determine whether further management actions are required at specific locations." It should also be noted that the success criteria listed in the Revegetation Plan were taken from the Rocky Mountain Arsenal (RMA) National Wildlife Refuge Habitat Restoration Plan (USFWS 1999) and are the criteria that is used at the RMA. So although three of the areas passed each of the criteria listed in the Revegetation Plan, this does not mean that the vegetation has established to a desirable level at either landfill as of 2006. A good healthy stand of vegetation is desirable on both landfills to protect the covers and provide good erosion control. Continued management and monitoring to promote a long-term, sustainable, vegetation cover on both landfills will continue to be pursued. Proactive management of the revegetation areas is critical to success. These data provide useful information for making management decisions and provide documentation of the successional changes at the revegetation locations that can then also be used to help improve revegetation techniques at the Site.

Summary

Monitoring was conducted at PLF and OLF during 2006. Results indicate that the vegetation has begun growing on the PLF and OLF, but is in the early stages of establishment. Ground cover from vegetation, rock, and litter (including erosion controls) is protecting the soil from erosion. The drought in 2006 limited some vegetation establishment and growth, but as normal precipitation amounts return it is expected that vegetation will continue to increase and ultimately provide good vegetation stands at these locations. Although three of the four locations monitored on the landfills met all four success criteria listed in the Revegetation Plan, this does not mean that the vegetation has established to the point where it needs to be on either landfill as of 2006. Proactive management of the revegetation areas will be conducted to establish a good stand of vegetation on the landfills and help control undesirable species.

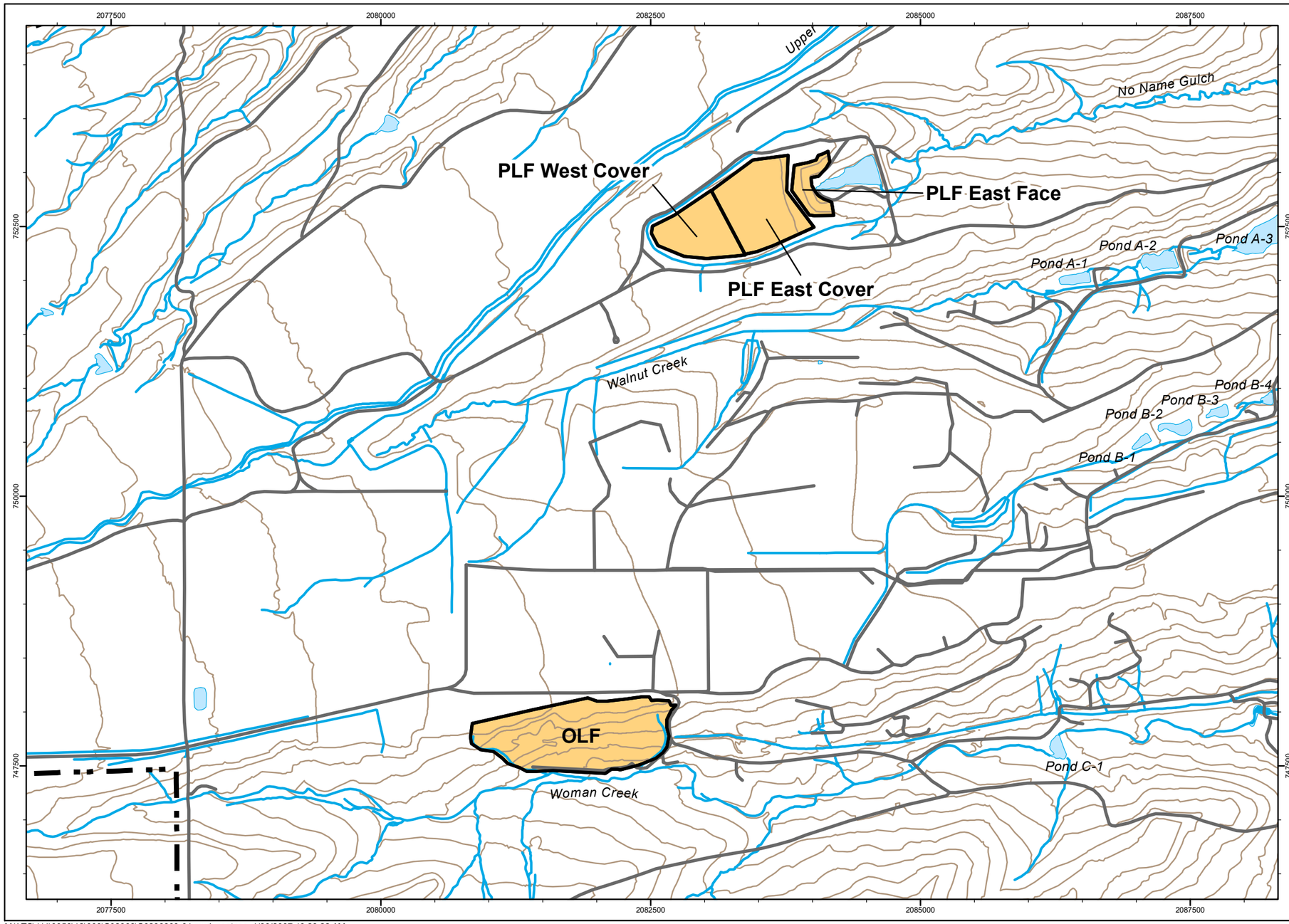
References

DOE, 2005. *Rocky Flats, Colorado, Site Revegetation Plan*, U.S. Department of Energy, Office of Legacy Management, Grand Junction, Colorado, December.

USFWS, 1999. *Rocky Mountain Arsenal (RMA) National Wildlife Refuge Habitat Restoration Plan*, Rocky Mountain Arsenal National Wildlife Refuge, U.S. Department of the Interior, Commerce City, Colorado.

2006 Present Landfill and Original Landfill Revegetation Monitoring Units

Figure 1



LEGEND

- Site boundary
- Road
- Stream, ditch, or other drainage feature
- Lake or pond
- Topographic contour (20-foot interval)
- 2006 Revegetation Units

N

SCALE IN FEET

1,000 500 0 1,000

STATE PLANE COORDINATE SYSTEM
COLORADO CENTRAL ZONE
NORTH AMERICAN DATUM OF 1927

U.S. DEPARTMENT OF ENERGY GRAND JUNCTION, COLORADO	Work Performed by **S.M. Stoller Corporation** Under DOE Contract No. DE-AC01-02GJ79491
DATE PREPARED: January 29, 2007	FILENAME: S0296800-01

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Table 1. 2006 Species Richness Summary at the PLF and OLF

Family	Scientific Name	Speccode	Native	Noxious Weed	PLF East Cover	PLF West Cover	PLF East Face	OLF
ASTERACEAE	Ambrosia psilostachya DC.	AMPS1	Y				X	
ASTERACEAE	Aster porteri Gray	ASPO1	Y		X			
ASTERACEAE	Carduus nutans L. ssp. macrolepis (Peterm.) Kazmi	CANU1	N	X				
ASTERACEAE	Centaurea diffusa Lam.	CEDI1	N	X	X	X	X	X
ASTERACEAE	Chrysanthemum leucanthemum L.	CHLE1	N	X				
ASTERACEAE	Cirsium arvense (L.) Scop.	CIAR1	N	X				X
ASTERACEAE	Conyza canadensis (L.) Cronq.	COCA1	Y		X		X	
ASTERACEAE	Grindelia squarrosa (Pursh.) Dun.	GRSQ1	Y		X	X	X	
ASTERACEAE	Lactuca serriola L.	LASE1	N		X	X	X	X
ASTERACEAE	Taraxacum officinale Weber	TAOF1	N		X	X		
ASTERACEAE	Tragopogon dubius Scop.	TRDU1	N			X		
BRASSICACEAE	Alyssum minus (L.) Rothmaler var. micranthus (C. A. Mey.) Dudley	ALMI1	N					X
BRASSICACEAE	Lepidium campestre (L.) R. Br.	LECA1	N		X	X	X	
CHENOPODIACEAE	Kochia scoparia (L.) Schrad.	KOSC1	N					X
CHENOPODIACEAE	Salsola iberica Senn. & Pau.	SAIB1	N					X
CONVOLVULACEAE	Convolvulus arvensis L.	COAR1	N	X		X		
FABACEAE	Melilotus alba Medic.	MEAL1	N			X		
FABACEAE	Melilotus officinalis (L.) Pall.	MEOF1	N		X	X		X
GERANIACEAE	Erodium cicutarium (L.) L'Her.	ERCI1	N	X		X		X
PLANTAGINACE	Plantago lanceolata L.	PLLA1	N			X		
POACEAE	Aegilops cylindrica Host	AECY1	N	X				X
POACEAE	Agropyron caninum (L.) Beauv. ssp. majus (Vasey) C. L. Hitchc.	AGCA1	Y		X	X	X	X
POACEAE	Agropyron smithii Rydb.	AGSM1	Y		X	X	X	X
POACEAE	Andropogon gerardii Vitman	ANGE1	Y		X	X		
POACEAE	Andropogon scoparius Michx.	ANSC1	Y		X	X		
POACEAE	Bouteloua curtipendula (Michx.) Torr.	BOCU1	Y		X	X	X	X
POACEAE	Bouteloua gracilis (H. B. K.) Lag ex Griffiths	BOGR1	Y		X		X	X
POACEAE	Bromus japonicus Thunb. ex Murr.	BRJA1	N			X		
POACEAE	Bromus tectorum L.	BRTE1	N	X	X	X		X
POACEAE	Buchloe dactyloides (Nutt.) Engelm.	BUDA1	Y		X	X		
POACEAE	Festuca pratensis Huds.	FEPR1	N			X		
POACEAE	Hordeum jubatum L.	HOJU1	Y			X		
POACEAE	Koeleria pyramidata (Lam.) Beauv.	KOPY1	Y			X		
POACEAE	Poa compressa L.	POCO1	N		X	X		
POACEAE	Triticum aestivum L.	TRAE1	N					X
SANTALACEAE	Comandra umbellata (L.) Nutt.	COUM1	Y		X			
SCROPHULARIACEAE	Linaria dalmatica (L.) Mill.	LIDA1	N	X				
SCROPHULARIACEAE	Verbascum thapsus L.	VETH1	N	X		X		
VERBENACEAE	Verbena bracteata Lag. & Rodr.	VEBR1	Y		X	X		
	Unknown species	UNKN						
		Total Number of Species			19	25	10	15
		Grand Total				35		15

Table 2. Seeded Species By Location

Family	Scientific Name	PLF	OLF
Graminoids			
POACEAE	Agropyron caninum	X	X
POACEAE	Agropyron dasystachum	X	X
POACEAE	Agropyron lanceolatus	X	
POACEAE	Agropyron smithii	X	X
POACEAE	Andropogon gerardii	X	
POACEAE	Andropogon scoparius		
POACEAE	Bouteloua curtipendula	X	X
POACEAE	Bouteloua gracilis	X	X
POACEAE	Buchloe dactyloides	X	X
POACEAE	Koleria pyrimidata	X	
POACEAE	Poa canbyi	X	
POACEAE	Sorghastrum nutans	X	
POACEAE	Sporobolus cryptandrus	X	
POACEAE	Stipa viridula	X	X
	Total # Species Seeded	13	7

Table 3. Number of Seeded Species Present in 2006 Summary

Location	# Species Seeded at Location	# Seeded Species Present in 2006	% Seeded Species Present in 2006
PLF East Cover	13	7	54
PLF West Cover	13	7	54
PLF East Face	7	4	57
OLF	7	4	57

Shaded locations pass success criteria in 2006.

Table 4. 2006 Rock, Litter, and Basal Vegetation Cover Summary

Location	Basal Veg Cover	Rock Cover	Litter Cover	Total Ground Cover
PLF East Cover	2.5	21.0	75.2	98.7
PLF West Cover	3.3	13.3	79.0	95.7
PLF East Face	2.5	9.8	90.0	102.3
OLF	3.1	11.3	85.0	99.3

All values are percentages.

Some values exceed 100% because of the use of cover class midpoints for data collection and analyses.

Shaded locations pass success criteria in 2006.

Table 5. 2006 Species Foliar Cover Summary at the PLF and OLF

						PLF East Cover		PLF West Cover		PLF East Face		OLF	
Scientific Name	Speccode	Growth Form	Native	Cool/ Warm Season	Noxious Weed	Absolute Cover (%)	Relative Cover (%)	Absolute Cover (%)	Relative Cover (%)	Absolute Cover (%)	Relative Cover (%)	Absolute Cover (%)	Relative Cover (%)
Alyssum minus (L.) Rothmaler var. micranthus (C. A. Mey.) Dudley	ALMI1	F	N									0.2	0.8
Centaurea diffusa Lam.	CEDI1	F	N		X	1.0	2.6	1.2	2.7	0.5	1.9	1.0	5.0
Cirsium arvense (L.) Scop.	CIAR1	F	N		X							0.1	0.4
Convolvulus arvensis L.	COAR1	F	N		X			0.2	0.4				
Erodium cicutarium (L.) L'Her.	ERCI1	F	N		X			1.3	3.1			0.6	2.9
Kochia scoparia (L.) Schrad.	KOSC1	F	N									0.7	3.3
Lactuca serriola L.	LASE1	F	N			0.5	1.3	0.8	1.9	1.8	6.6	1.6	7.9
Lepidium campestre (L.) R. Br.	LECA1	F	N			0.2	0.4	0.2	0.4	0.5	1.9		
Melilotus alba Medic.	MEAL1	F	N					0.2	0.4				
Melilotus officinalis (L.) Pall.	MEOF1	F	N			1.3	3.5	1.3	3.1			1.3	6.2
Plantago lanceolata L.	PLLA1	F	N					0.2	0.4				
Salsola iberica Senn. & Pau.	SAIB1	F	N									0.7	3.3
Taraxacum officinale Weber	TAOF1	F	N			0.2	0.4	0.2	0.4				
Tragopogon dubius Scop.	TRDU1	F	N					0.2	0.4				
Verbascum thapsus L.	VETH1	F	N		X			0.3	0.8				
Ambrosia psilostachya DC.	AMPS1	F	Y							1.8	6.6		
Aster porteri Gray	ASPO1	F	Y			0.2	0.4						
Conyza canadensis (L.) Cronq.	COCA1	F	Y			0.5	1.3			0.3	0.9		
Comandra umbellata (L.) Nutt.	COUM1	F	Y			0.2	0.4						
Grindelia squarrosa (Pursh.) Dun.	GRSQ1	F	Y			0.2	0.4	0.5	1.2	1.5	5.7		
Verbena bracteata Lag. & Rodr.	VEBR1	F	Y			2.3	6.1	4.7	10.9				
Aegilops cylindrica Host	AECY1	G	N	C	X							0.6	2.9
Bromus japonicus Thunb. ex Murr.	BRJA1	G	N	C				0.2	0.4				
Bromus tectorum L.	BRTE1	G	N	C	X	0.2	0.4	0.2	0.4			0.7	3.3
Festuca pratensis Huds.	FEPR1	G	N	C				1.3	3.1				
Poa compressa L.	POCO1	G	N	C		0.2	0.4	0.7	1.6				
Triticum aestivum L.	TRAE1	G	N	C								2.6	12.8
Agropyron caninum (L.) Beauv. ssp. majus (Vasey) C. L. Hitchc.	AGCA1	G	Y	C		14.7	38.6	21.2	49.2	7.8	29.2	6.4	31.8
Agropyron smithii Rydb.	AGSM1	G	Y	C		2.2	5.7	3.0	7.0	6.5	24.5	3.2	15.7
Hordeum jubatum L.	HOJU1	G	Y	C				0.2	0.4				
Koeleria pyramidata (Lam.) Beauv.	KOPY1	G	Y	C				0.2	0.4				
Andropogon gerardii Vitman	ANGE1	G	Y	W		5.5	14.5	3.0	7.0				
Andropogon scoparius Michx.	ANSC1	G	Y	W		0.2	0.4	0.2	0.4				
Bouteloua curtipendula (Michx.) Torr.	BOCU1	G	Y	W		6.2	16.2	0.7	1.6	3.0	11.3	0.5	2.5
Bouteloua gracilis (H. B. K.) Lag ex Griffiths	BOGR1	G	Y	W		0.5	1.3			3.0	11.3	0.3	1.2
Buchloe dactyloides (Nutt.) Engelm.	BUDA1	G	Y	W		2.0	5.3	1.2	2.7				
Total Foliar Cover						38.0	100.0	43.0	100.0	26.5	100.0	20.2	100.0
Total Forb Cover						6.5	17.1	11.2	26.0	6.3	23.6	6.0	29.8
Total Non-Native Forb Cover						3.2	8.3	6.0	14.0	2.8	10.4	6.0	29.8
Total Native Forb Cover						3.3	8.8	5.2	12.0	3.5	13.2	0.0	0.0
Total Graminoid Cover						31.5	82.9	31.8	74.0	20.3	76.4	14.2	70.2
Total Non-Native Graminoid Cover						0.3	0.9	2.3	5.4	0.0	0.0	3.8	19.0
Total Native Graminoid Cover						31.2	82.0	29.5	68.6	20.3	76.4	10.3	51.2
Total Native Cover						34.5	90.8	34.7	80.6	23.8	89.6	10.3	51.2
Total Non-Native Cover						3.5	9.2	8.3	19.4	2.8	10.4	9.8	48.8
Total Warm-Season Graminoid Cover						14.3	37.7	5.0	11.6	6.0	22.6	0.8	3.7
Total Cool-Season Graminoid Cover						17.2	45.2	26.8	62.4	14.3	53.8	13.4	66.5
Total Noxious Weed Cover						1.2	3.1	3.2	7.4	0.5	1.9	2.9	14.5

Absolute Cover = The percentage of the number of hits on a species out of the total number of hits possible.
Relative Cover = The percentage of the number of hits on a species out of the total number of vegetation hits.
Native Categories: Y = Native, N = Non-Native
Growth Form Categories: F = Forb, G = Graminoid
Cool/Warm Season Categories: C = Cool-Season Graminoid, W = Warm-Season Graminoid
Noxious Weed Category: X = Noxious Weed (listed on May 2006 Colorado State Noxious Weed List)
Shaded cells indicate success criteria were met in 2006.

Table 6. Success Criteria Summary for Revegetation Locations in 2006

Location	Minimum of 50% of Seeded Species Present	70% Ground Cover of Litter, Rock, and Vegetation	30% Relative Cover of Desired Species	No Single Species With >45% Relative Cover	Overall Pass/Fail
PLF East Cover	Pass	Pass	Pass	Pass	Pass
PLF West Cover	Pass	Pass	Pass	Fail	Fail
PLF East Face	Pass	Pass	Pass	Pass	Pass
OLF	Pass	Pass	Pass	Pass	Pass

Shaded locations pass success criteria in 2006.